

Characterisation of Screen-Printed Carbon Electrodes

Andy Hicks¹

Dr Sam Lunn², Dr James Iacobini², Dr Andrew Pike¹, and Dr Ben Horrocks¹

1) Newcastle University, Bedson Building, Newcastle upon Tyne, United Kingdom

2) Palintest, Palintest House, Gateshead, United Kingdom

A.hicks@newcastle.ac.uk

The standard heterogeneous rate constant (k^0) is a measure of the rate of electron transfer at the electrode surface measured in the units cm s^{-1} during a faradaic reaction. The k^0 of test redox couples such as $[\text{Ru}(\text{NH}_3)_6]^{3/2+}$, and $[\text{Fe}(\text{CN})_6]^{4/3-}$ was calculated from cyclic voltammetry (CV) data using the methods of Nicholson and Shain for quasi-reversible electrochemical reactions, or the convolution method of Savéant and Tessier.^{1, 2} These values were used as a means of characterising the electrocatalytic ability of different screen printed carbon electrodes fabricated with commercially available carbon inks (containing graphite or graphene), as well as commercially available inks drop cast with gold nanoparticles. Differential capacitance measurements also provide insight into the behaviour of different electrode materials, with carbon electrodes typically showing a C_d of around $5 \mu\text{F cm}^{-2}$, and metal electrodes of around $20 \mu\text{F cm}^{-2}$. Gold nanoparticles are seen to provide around a 20 fold increase in k^0 in comparison to bare carbon electrode for the reaction of $[\text{Fe}(\text{CN})_6]^{4/3-}$ from $(1.57 \pm 0.4 \times 10^{-4} \text{ cm s}^{-1})$ to $(2.58 \pm 0.1 \times 10^{-2} \text{ cm s}^{-1})$. Differential capacitance measurements show a C_d for Au nanoparticle coated electrodes close to that of a bulk metal electrode. XPS data shows a surface coverage of less than 4%, showing that only small quantities of nanoparticles are required, making this a cheap and facile means of increasing the electrocatalytic ability of screen-printed carbon electrodes.

References

- [1]. R. S. Nicholson and I. Shain, *Analytical Chemistry*, 36 (1964), 706-723.
- [2]. J. M. Savéant and D. Tessier, *Journal of Electroanalytical Chemistry and Interfacial Electrochemistry*, 61 (1975), 251-263.